

# Resolving the Paradoxes of Discounting in Environmental Decisions

Joseph H. Guth\*

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## I. INTRODUCTION

Carbon emissions, radioactive waste, and species extinctions affect not just the present but also the future, sometimes the distant future. As our impact on the Earth mounts, the specter of the future that we are creating is looming larger, becoming more insistent. The advent of global warming, especially, impresses upon us that environmental degradation is implicating not only our own welfare but also that of future generations. As we consider taking stronger steps to protect the environment, topics that may seem arcane, such as “cost-benefit analysis” and “discounting,” are being drawn into the public discourse.<sup>1</sup> Discounting, it turns out, holds the key to understanding why our economic and legal systems are having such a difficult time controlling mounting, long-term environmental degradation.

Our prevailing framework for balancing economic and environmental interests when they conflict is to compare the costs of individual activities with their benefits. This decision-making structure starts with the presumption that economic activity is socially beneficial, that is, produces a

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<sup>1</sup> See, e.g., John Broome, *The Ethics of Climate Change: Pay Now or Pay More Later?*, SCI. AM., May 19, 2008 (discussing climate change, future generations, cost-benefit analysis, and discounting) (unpaginated document), available at <http://www.sciam.com/article.cfm?id=the-ethics-of-climate-change>.

net benefit for the society.<sup>2</sup> In keeping with this presumption, environmental laws can restrain damage done by the market economy, but they generally place the burden of proof on the government to demonstrate that the benefits of a regulation outweigh its costs.<sup>3</sup> Within this decision-making framework, a particular analytical problem arises whenever we obtain the benefits at one time while bearing the costs at another. When this happens, we must compare the value of costs and benefits that accrue in the future, sometimes the distant future, with the value of those that accrue in the present. This analytical comparison is handled through a technique known as “discounting.”

Discounting is a mathematical technique for determining the value to us today, the “present value,” of costs or benefits that occur in the future. The technique alters future values by a specified percentage every year, which is known as the “discount rate.” For example, employing a discount rate of 3 percent or 7 percent would reduce the value of future costs and benefits by 3 percent or 7 percent per year, respectively, to calculate their present value. Employing higher discount rates causes future values to decrease more rapidly, which results in attributing lower present values to future costs and benefits. A discount rate of zero would attribute the same value to future as to present costs and benefits. A negative discount rate would attribute a higher present value to future costs and benefits than to present ones.<sup>4</sup>

The outcome of cost-benefit-driven decisions is highly dependent on how discounting is used. Studies show that for many regulations the choice of discounting method can have a profound effect on whether regulations are judged cost-effective.<sup>5</sup> In one striking example, a 2006 report from the British Treasury, *The Stern Review on the Economics of Climate Change*, found that global warming would impose large costs on the future, warranting

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<sup>2</sup> See HERMAN E. DALY & JOSHUA FARLEY, *ECOLOGICAL ECONOMICS: PRINCIPLES AND APPLICATIONS* 3–4 (2004) (asserting that the traditional goal of economics is to increase human welfare by growth in market value of goods and services produced by the economy).

<sup>3</sup> See RICHARD L. REVESZ & MICHAEL A. LIVERMORE, *RETAKING RATIONALITY—HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT THE ENVIRONMENT AND OUR HEALTH* 10, 12, 14 (2008) (arguing that cost-benefit analysis ensures that government regulation increases economic efficiency, maximizes the net-benefit of regulation, and helps maximize wealth production by the economy); Joseph H. Guth, *Law for the Ecological Age*, 9 VT. J. ENVTL. L., 431, 450–73 (2008), available at <http://www.vjel.org/journal/pdf/VJEL10068.pdf> [hereinafter Guth, *Law for the Ecological Age*] (environmental statutes and common law presume economic activity provides net benefit to society and generally permit environmental regulation or liability only where government or plaintiffs can prove otherwise); Joseph H. Guth, *Cumulative Impacts—Death-Knell for Cost Benefit Analysis in Environmental Decisions*, BARRY L. REV. (forthcoming 2009) [hereinafter Guth, *Cumulative Impacts*] (discussing role of cost-benefit analysis in making decisions that affect the environment).

<sup>4</sup> Discount rates are independent of and in addition to inflation, which is accounted for separately and should be ignored in this discussion.

<sup>5</sup> See, e.g., Lisa Heinzerling, *Regulatory Costs of Mythic Proportions*, 107 YALE L.J. 1981, 1984–85, 2069–70 (1998) (discounting value of future human lives saved causes many environmental health regulations to seem far less cost-effective).

substantial and immediate preventive action.<sup>6</sup> This conclusion differs from that of other economists who have found that global warming justifies only modest action now.<sup>7</sup> The difference is driven by Sir Stern's choice of a very low positive discount rate rather than the higher rate used by other economists.<sup>8</sup> Thus, under our current environmental decision-making structure, whether we should take strong immediate action on the critical issue of global warming turns on the seemingly arcane choice of a discount rate.

While some debate exists over the importance of future generations, most discounting analysts agree that we should hold them equal to our own.<sup>9</sup> One might think that we could determine how to use a simple mathematical device like discounting to fulfill this obligation to future generations. But as we will see, no particular method always furthers that objective. Each particular method of using discounting or even not using it can lead to inconsistencies and perverse results. Unfortunately, the answer to the question of whether a particular discount rate benefits the future or the present is: it depends.

Discounting does not provide a coherent approach to protecting the interests of future generations. This Article will show that the reason originates with flaws in the assumptions underlying the cost-benefit decision-making framework itself. These outdated underlying assumptions are inconsistent with the modern realities of environmental degradation. If we are to protect the ecological integrity of the biosphere for future generations, we will have to adopt new assumptions that accord with our new ecological reality. Then we must use these new assumptions to build a new structure for making environmental decisions that will make not just discounting but cost-benefit analysis itself all but irrelevant.

## II. THE "PARADOXES" OF DISCOUNTING

Many economists hold that cost-benefit analysis should apply some positive discount rate to all costs and benefits, reflecting their conclusion that we should place less value on benefits received in the future than those received in the present and, symmetrically, should prefer to incur costs in the

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<sup>6</sup> NICHOLAS STERN, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE, at vi (Oct. 30, 2006) (Summary of Conclusions), available at [http://www.hm-treasury.gov.uk/stern\\_review\\_report.htm](http://www.hm-treasury.gov.uk/stern_review_report.htm).

<sup>7</sup> See David A. Weisbach & Cass R. Sunstein, *Introduction to Symposium On Intergenerational Equity and Discounting*, 74 U. CHI. L. REV. 1, 2 (2007) (discussing difference between results of Stern report and of models used by other analysts); WILLIAM NORHAUS, A QUESTION OF BALANCE—WEIGHING THE OPTIONS ON GLOBAL WARMING POLICY 1–29 (2008), available at [http://nordhaus.econ.yale.edu/Balance\\_2nd\\_proofs.pdf](http://nordhaus.econ.yale.edu/Balance_2nd_proofs.pdf).

<sup>8</sup> For discussion disapproving the near-zero discount rate used in the Stern Review and analysis of alternative approaches, see NORHAUS, *supra* note 7, at 9–11, 59–62, 165–91.

<sup>9</sup> Weisbach & Sunstein, *supra* note 7, at 1–2 (noting that most discounting analysts agree that all generations count equally).

future rather than today.<sup>10</sup> In a 2001 survey, 2160 economists most commonly chose a discount rate of 2 percent (with a median choice of 3 percent and a mean of 4 percent) for calculating the present value of the costs of long-term environmental problems.<sup>11</sup>

Perhaps reflecting this widespread view among economists, the U.S. government is strongly committed to using cost-benefit analysis and positive discount rates in developing environmental regulations. Presidential Executive Order No. 12,866, signed by President Clinton, commands all federal agencies to propose or adopt regulations, including environmental regulations, only if they can show that the benefits justify the costs (unless a particular statute requires otherwise).<sup>12</sup> The White House Office of Management and Budget (OMB) actively enforces Executive Order No. 12,866, and it has issued detailed guidance on the conduct of cost-benefit analysis,<sup>13</sup> including the use of positive discount rates.<sup>14</sup> The OMB recommends that agencies perform two separate analyses of their regulations, one employing a 3 percent discount rate and one employing a 7 percent discount rate. The OMB recites the 7 percent rate as the average before-tax rate of return to private capital in the U.S. economy, and contends that it approximates the opportunity cost of capital and is therefore the appropriate discount rate whenever a regulation displaces the use of capital

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<sup>10</sup> Paul R. Portney & John P. Weyant, *Introduction* to DISCOUNTING AND INTERGENERATIONAL EQUITY 6–7 (Paul R. Portney & John P. Weyant eds., Resources for the Future 1999) (“[O]ne of the most important conclusions” of this workshop proceeding is that all but one of the authors agree that it is “essential” that future benefits and costs be discounted at a positive rate, particularly for long time frames.); Weisbach & Sunstein, *supra* note 7, at 3 (“[M]ost of the authors [of articles in this symposium volume] believe that a positive discount rate is appropriate.”).

<sup>11</sup> Geoffrey Heal, *Discounting: A Review of the Basic Economics*, 74 U. CHI. L. REV. 59, 72 (2007) (summarizing a 2001 survey of economists reported in Martin L. Weitzman, *Gamma Discounting*, 91 AM. ECON. REV. 260, 266–69 (2001)).

<sup>12</sup> Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Sept. 30, 1993), available at <http://www.archives.gov/federal-register/executive-orders/pdf/12866.pdf> (“Each agency shall . . . propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.”). See also REVESZ & LIVERMORE, *supra* note 3, at 21–45, 151–69 (recounting the history and current applicability of Exec. Order No. 12,866).

<sup>13</sup> See OFF. OF MGMT. & BUDGET, EXEC. OFF. OF THE PRESIDENT, CIRCULAR A–4 (Sept. 17, 2003) (providing detailed instructions to all federal agencies on conduct of regulatory cost-benefit analysis under E.O. 12,866), available at <http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf>. Extensive ongoing evaluation of regulations under Exec. Order No. 12,866 by the Office of Information and Regulatory Affairs (OIRA), an office within OMB, both before they are promulgated and after they issue, is reflected in OMB’s Annual Reports to Congress on the Costs and Benefits of Federal Regulations (*compiled at* <http://www.whitehouse.gov/omb/legislative/index.html>). See also REVESZ & LIVERMORE, *supra* note 3, at 21–45, 151–69 (providing extensive history of OIRA and OMB influence over administrative agencies, especially the Environmental Protection Agency (EPA)).

<sup>14</sup> OFF. OF MGMT. & BUDGET, *supra* note 13, at 32. See also John D. Graham, *Valuing the Future: OMB’s Refined Position*, 74 U. CHI. L. REV. 51, 51–57 (2007) (discussing OMB Circular A–4, various discount rates, and when they should be used).

by the private sector.<sup>15</sup> OMB recites the 3 percent rate as the historical real rate of return on long-term government debt, and believes that it approximates the social preference for present consumption over future consumption and is therefore the appropriate discount rate whenever a regulation primarily affects private consumption (e.g., by affecting the price of consumer products).<sup>16</sup> In some circumstances, the OMB believes a higher rate of 10 percent,<sup>17</sup> or sometimes a rate below 3 percent,<sup>18</sup> could be appropriate and recommends regulatory agencies consider these as well.

The U.S. Environmental Protection Agency (EPA) has issued similar guidance on the use of positive discount rates.<sup>19</sup> In a recent example, the EPA calculated the costs and benefits of a Clean Air Act regulation using both 3 percent and 7 percent discount rates.<sup>20</sup> Analysts who have broadly examined agency compliance with the OMB guidelines on discounting find that agencies now frequently employ discounting, though in varying ways.<sup>21</sup>

Those who support the use of positive discount rates offer several reasons for concluding that future costs and benefits are worth less than present ones.<sup>22</sup> One is the empirical evidence that people have what is called a “positive time preference,” meaning that people actually prefer to receive benefits now rather than receive the same benefits in the future.<sup>23</sup> Another is that if the economy continues to grow as it has for most of U.S. history, consumption of particular benefits now will be of greater marginal utility than in the future when we are richer and our consumption is greater.<sup>24</sup> The idea is that any particular cost or benefit will constitute a smaller portion of society’s total wealth, and thus be of less marginal value, in the future than in the present.

The main reason, however, is grounded in the opportunity cost associated with spending resources now rather than later.<sup>25</sup> The logic is that if we spend

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<sup>15</sup> OFF. OF MGMT. & BUDGET, *supra* note 13, at 33.

<sup>16</sup> *Id.*

<sup>17</sup> *Id.* at 34.

<sup>18</sup> *Id.* at 36.

<sup>19</sup> ENVTL. PROTECTION AGENCY, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 52 (2000), available at <http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/guidelines.html>. See also REVESZ & LIVERMORE, *supra* note 3, at 95–96 (discussing EPA cost-benefit guidelines).

<sup>20</sup> Clean Air Interstate Rule, 70 Fed. Reg. 25, 162 (May 12, 2005).

<sup>21</sup> See W. Kip Viscusi, *Rational Discounting For Regulatory Analysis*, 74 U. CHI. L. REV. 209, 224–26 (2007) (analyzing the use of discounting by regulatory agencies).

<sup>22</sup> See OFF. OF MGMT. & BUDGET, *supra* note 13, at 32. See also Heal, *supra* note 11, at 71–77; Graham, *supra* note 14, at 52–54.

<sup>23</sup> See, e.g., OFF. OF MGMT. & BUDGET, *supra* note 13, at 32.

<sup>24</sup> *Id.*; Tyler Cowan, *Caring about the Distant Future: Why It Matters and What It Means*, 74 U. CHI. L. REV. 5, 6–7 (2007).

<sup>25</sup> OFF. OF MGMT. & BUDGET, *supra* note 13, at 32.

money to obtain particular benefits today, we will have forgone the opportunity to invest the money, let it grow in value, and then have more real wealth in the future with which to purchase benefits. In effect, present benefits are thought to cost more than future benefits because when we spend resources now to obtain them, we lose the opportunity to invest those resources and thereby grow in wealth.

What about the simple idea that future costs and benefits are worth the same as present ones and should not be discounted at all (which entails applying a discount rate of zero)? Many economists argue that this would lead to numerous “anomalies” or “paradoxes.”<sup>26</sup> Consider, for example, environmental damage that permanently affects all future generations, such as losing a species or global warming. The total cost of losses that are permanent would accrue every year for thousands of years and reach a vast, even infinite, accumulated value. These costs would seem to justify extensive, immediate social actions and expenditures to avoid them. Some analysts view this outcome as “absurd,” holding that “not even Greenpeace” would want to spend current resources commensurate with the large costs associated with undiscounted, long-term environmental damage.<sup>27</sup> Discounting avoids this “absurd” result by mathematically reducing the apparent costs of future environmental degradation.

A second commonly-cited “anomaly” of using a zero discount rate is the fear that it would create an incentive to defer expenses that would generate a continual stream of future benefits, and thereby cause us to purchase fewer benefits today rather than more.<sup>28</sup> This is because, according to the theory, if we defer an expense, then we can invest the resources, wait for them to grow, and then use them to create an even larger continual stream of future benefits. Waiting would be especially to our advantage because technological improvements will likely make solving problems less costly in the future.<sup>29</sup> If we were really to consider future benefits as worth just as much as today’s, the thinking goes, we would always rationally defer spending money so as to someday obtain a larger future continual stream of future benefits.<sup>30</sup>

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<sup>26</sup> Viscusi, *supra* note 21, at 216–17 (outlining four “anomalies” caused by failure to discount, concluding that “serious economic discussions do not suggest that zero discount rates are appropriate”); Cass R. Sunstein & Arden Rowell, *On Discounting Regulatory Benefits: Risk, Money and Intergenerational Equity*, 74 U. CHI. L. REV. 171, 175–78 (2007) (outlining “paradoxes” caused by zero discount rate).

<sup>27</sup> Richard A. Posner, *Efficient Responses To Catastrophic Risk*, 6 CHI. J. INT’L L. 511, 519 (2006) (calculating that if global warming causes \$100 billion in damages per year for one million years, the undiscounted value of that damage is \$100 quadrillion).

<sup>28</sup> See, e.g., Viscusi, *supra* note 21, at 217.

<sup>29</sup> *Id.*

<sup>30</sup> See Douglas A. Kysar, *Discounting . . . on Stilts*, 74 U. CHI. L. REV. 118, 122–24 (2007). This rationale depends on the unlikely assumption that we actually would invest the unspent resources and set them aside for future purposes. *Id.*

Analysts have suggested negative discount rates as well.<sup>31</sup> But they generally discard this option out of hand.<sup>32</sup> At the very least, a negative discount rate would make both of the zero-discount rate “anomalies” discussed above even worse.

Despite all these arguments in favor of positive discount rates, application of any positive rate can produce its own set of anomalies and difficulties, especially when applied to long time periods. Some writers have referred to discounting with positive rates as “shrinking the future,” for the mathematics of discounting makes effects in the distant future, even very large effects, seem insignificant compared to effects in the present.<sup>33</sup> For example, discounting at a rate of 5 percent per year causes the value of any future cost or benefit to be mathematically reduced by a factor of 131 in 100 years and by a stunning factor of over 39 billion in 500 years.<sup>34</sup> Discounting can make a dollar’s worth of benefits today appear to outweigh millions or even billions of dollars of damage in the future. Saving one life today can appear more valuable than saving billions of people in the future.<sup>35</sup> The entire global economy of several centuries in the future can be discounted to just two dollars per person today.<sup>36</sup> Thus, positive discount rates make using resources to obtain modest current benefits appear wiser than using them to obtain larger benefits, even far larger benefits, in the future.

This powerful effect of positive discount rates on cost-benefit decision-making ensures that debate continues to rage over the details of how and when to use them. One problem is to identify the “correct” positive discount rate, and the range of options only grows as economists and lawyers continue to struggle. Some have suggested using different discount rates for projects involving different time frames, ranging from 15 percent (5 years) to 5 percent (30 to 50 years), down to 2 percent (100 years).<sup>37</sup> Others have suggested “hyperbolic discounting” in which the discount rate is not constant, but varies over the time period involved.<sup>38</sup> Still others have insisted the same

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<sup>31</sup> Partha Dasgupta, Karl-Goran Maler & Scott Barrett, *Intergenerational Equity, Social Discount Rates, and Global Warming*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 10, at 51–77.

<sup>32</sup> Portney & Weyant, *supra* note 10, at 6 (observing that their volume’s one proposal for zero or negative discount rates “would be an unusual case”); Sunstein & Rowell, *supra* note 26, at 176 (discussing negative discount rates).

<sup>33</sup> FRANK ACKERMAN & LISA HEINZERLING, PRICELESS—ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING 179–203 (2004).

<sup>34</sup> Cowen, *supra* note 24, at 8.

<sup>35</sup> Sunstein & Rowell, *supra* note 26, at 176 (2007) (quoting Frank Ackerman & Lisa Heinzerling, *Pricing the Priceless*, 150 U. PA. L. REV. 1553, 1571 (2002)).

<sup>36</sup> See Portney & Weyant, *supra* note 10, at 5.

<sup>37</sup> Heal, *supra* note 11, at 68–69.

<sup>38</sup> Maureen Cropper & David Laibson, *The Implications of Hyperbolic Discounting for Project Evaluation*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 10, at 163–72.

discount rate should be applied to all generations.<sup>39</sup> One prominent commentator has argued that because evidence from the American political system shows that Americans place little value on future generations, benefits occurring in the distant future should be deemed to have zero value, and for long time periods, “the effective discount rate should be infinity.”<sup>40</sup>

Analysts also struggle over whether to discount future human lives and health when they can be protected by environmental health regulations adopted today. Some object to discounting human lives, saying that lives in the future are worth just as much as lives today. After all, they point out, people cannot be put in a bank where they would somehow “grow” like money can.<sup>41</sup> Others object based on the empirical evidence, which shows that people do not discount future lives and health the same way they do money and other forms of consumption—especially not across generations.<sup>42</sup> On the other hand, supporters counter that lives and health are not what is really being discounted, but rather the underlying expenses needed to save them, so that failing to discount such benefits while discounting the costs would lead to various paradoxes as well.<sup>43</sup> The OMB insists that future lives saved and human health benefits should be discounted. The OMB claims that people prefer health gains today to identical gains in the future and discounting the costs, but not the benefits, would perversely lead us to defer expenses perpetually, in order to obtain greater gains later.<sup>44</sup> Courts have agreed.<sup>45</sup>

Another difficulty is that, as we have seen, positive discount rates minimize even serious future ecological degradation. Some commentators have proposed fixes for this inconvenience, suggesting that discounting be adjusted or eliminated for environmental impacts that are “catastrophic” and “irreversible,” with various examples including global warming, species loss, uranium leaks out of containment ponds, ozone depletion, and hazardous waste leaching into ground water.<sup>46</sup> But these commentators are far from

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<sup>39</sup> Viscusi, *supra* note 21, at 209–46.

<sup>40</sup> Richard A. Posner, *Agencies Should Ignore Distant Future Generations*, 74 U. CHI. L. REV. 139, 139–40 (2007).

<sup>41</sup> ACKERMAN & HEINZERLING, *supra* note 33, at 191.

<sup>42</sup> THOMAS O. MCGARRITY, SIDNEY SHAPIRO & DAVID BOLLIER, SOPHISTICATED SABOTAGE—THE INTELLECTUAL GAMES USED TO SUBVERT RESPONSIBLE REGULATION 183–89 (2004); Kysar, *supra* note 30, at 121–22; Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives*, 99 COLUM. L. REV. 941, 1015 (1999); REVEZ & LIVERMORE, *supra* note 3, at 95–106, 107–17 (arguing that discounting can be used reasonably for latent harm within a generation only with adjustments, and should not be used at all for future generations).

<sup>43</sup> Sunstein & Rowell, *supra* note 26, at 174–78.

<sup>44</sup> OFF. OF MGMT. & BUDGET, *supra* note 13, at 34.

<sup>45</sup> See *Corrosion Proof Fittings v. EPA*, 947 F.2d 1201, 1218 (5th Cir. 1991) (vacating asbestos regulation, stating future lives saved must be discounted as well as costs to ensure fair comparison).

<sup>46</sup> ACKERMAN & HEINZERLING, *supra* note 33, at 185–86; Sunstein & Rowell, *supra* note 26, at 189, 204–05 n.77.

resolving which environmental impacts should receive such exceptional treatment or exactly how to make decisions in such cases.

Finally, projecting costs and benefits into the future brings into sharp relief the distributional issue of who receives the benefits and who bears the costs. Numerous difficult conflicts of interest exist not just between current and future generations, but also between rich and poor societies and the rich and poor members of particular societies. These divisions become more or less acute depending on how government intervenes in the economy, and the choice of discount rate dramatically influences what interventions the government is able to justify using cost-benefit analysis.<sup>47</sup>

This array of issues gives many economists pause. As the organizers of a discounting workshop involving twenty leading economists put it:

[I]t is impossible to read these papers without getting a sense of the unease even the best minds in the profession feel about discounting, due to the technical complexity of the issues and their ethical ramifications. This unease is expressed most directly by [Nobel Prize winner] Robert Solow. In his foreword [to this volume], he writes, “Maybe the idea of a unitary decision maker—like an optimizing individual or a wise or impartial advisor—is not very helpful when it comes to choice of policies that will have distant-future effects about which one can now know hardly anything.”<sup>48</sup>

This has led even some analysts who generally support cost-benefit analysis to challenge the use of discounting to account for our long-term obligations to future generations. For example, law professor Richard Revesz argues that discounting across multiple generations is unethical because it unavoidably privileges the current generation. Whatever reasons a person might use to make cost-benefit tradeoffs in his or her own lifetime do not apply across generations and so cannot justify cross-generational discounting.<sup>49</sup> Professor Revesz urges that determining our responsibilities to future generations must move from debates over discounting to other kinds of explicitly ethical debates, including frank consideration of distributional issues in the present and the future and prevention of catastrophic environmental harms and destruction of unique natural resources.<sup>50</sup>

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<sup>47</sup> See Matthew D. Adler, *Economic Growth and the Interests of Future (and Past and Present) Generations: A Comment on Tyler Cowen*, 74 U. CHI. L. REV. 41, 41–49 (2007) (analyzing effects of different kinds of economic growth on the welfare of society); Portney & Weyant, *supra* note 10, at 6–7 (discussing discomfort many economists feel with distributional implications of different forms of discounting).

<sup>48</sup> Portney & Weyant, *supra* note 10, at 5 (introducing volume collecting workshop papers).

<sup>49</sup> Revesz, *supra* note 42, at 1015–18; see also REVEZ & LIVERMORE, *supra* note 3, at 107–17 (concluding discounting is inappropriate for evaluating impacts on future generations).

<sup>50</sup> Revesz, *supra* note 42, at 1015–16.

Similarly, noting that either discounting or not discounting can lead to “absurdities”<sup>51</sup> and that neither will always benefit future generations, Professor Cass Sunstein and Arden Rowell urge:

It follows that the moral obligations of current generations should be uncoupled from the question of discounting, because neither discounting nor refusing to discount is an effective way of ensuring that those obligations are fulfilled. The moral issues should be investigated directly, and they should be disentangled from the practice of discounting.<sup>52</sup>

But the question remains: why is it that cost-benefit analysis, with or without discounting, is unable to produce any coherent approach to the protection of future generations (whatever particular ethical stance one takes on that question)? What is the reason for the “absurdities” and “paradoxes” that so trouble economists and lawyers alike? Until we understand this, we will continue struggling to invent exceptions and fixes for cost-benefit analysis and remain unable to develop any alternative, more coherent structure for making environmental decisions with long-term implications.

The baffling debates over discounting remind one of the intricate Ptolemaic systems of epicycles that were once needed to explain observed planetary motions while retaining Aristotle’s belief that the Earth is at the center of the solar system.<sup>53</sup> Surely, when a theoretical construct leads to excessive complexity and paradoxical conclusions, one should look to the assumptions lying at the foundation of that construct. And so it is with discounting. Resolving the paradoxes of discounting requires us to step back and out to a level of thought at which starting assumptions are made. Just as Copernicus reexamined the Aristotelian assumptions in order to solve the mystery of planetary motions, we must reexamine the assumptions that have led our economic and legal systems to cost-benefit analysis and discounting in the first place.

### III. THE ENDLESS-GROWTH ASSUMPTIONS UNDERLYING COST-BENEFIT DECISION-MAKING

Former World Bank economist Herman Daly has described what he calls the “pre-analytic vision,” the set of starting assumptions that mainstream

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<sup>51</sup> Weisbach & Sunstein, *supra* note 7, at 1–2 (noting that both discounting and not discounting create “absurdities”).

<sup>52</sup> Sunstein & Rowell, *supra* note 26, at 199. *See also* Kysar, *supra* note 30, at 120 (expressing hope that after publication of papers from 2006 Symposium those interested in long-term policymaking will be able to put discounting aside and “focus instead on the more important task of conceiving and realizing equitable relations between human generations”).

<sup>53</sup> Economist Herman Daly has noted the resemblance between what he calls ad hoc elements of current neoclassical economic theories and the system of epicycles once needed to explain astronomical observations. HERMAN E. DALY, *BEYOND GROWTH* 34 (1996).

economics is built upon.<sup>54</sup> According to this vision, our economic and legal systems assume that the human economy can grow forever, and indeed our society's overriding macroeconomic goal is to ensure permanent economic growth. No limit is envisioned in the total scale of the economy or in our use of the Earth's resources. Particular resources are obviously limited in supply. But it is assumed that all forms of natural capital, including both resources (such as oil and fisheries) and pollution sinks (such as air and water), can be replaced either by other natural resources or by human capital and technology. Thus, we need not worry if even valuable resources and pollution sinks become exhausted. Once they become scarce and therefore expensive, we will be motivated to find substitutes which, it is assumed, we will always be able to do. Though the market may not contain prices for certain valuable natural resources (e.g., clean air, clean water, wetlands), and therefore can lead only to their exhaustion, these market flaws are not thought to be serious enough to disrupt the overarching vision. Environmental assets like clean air and water are viewed as "amenities" that we can obtain whenever we feel we can afford them. According to this economic vision, each and every portion of the biosphere can and should be liquidated whenever the market justifies it.

The logic of this pre-analytic vision leads inexorably to cost-benefit analysis to guide environmental decision-making. Every economic activity contributes to the general welfare as long as its benefits outweigh its costs. As long as the economic and legal systems prevent activities that do not provide a net benefit, human welfare is best served by maximum economic growth. As net economic benefits grow forever, the benefits and costs may also grow forever. If there is no reason to value a particular element of the natural world other than for its worth in an unfettered market, then environmental losses, like any other kind of loss, should be tolerated as long as they are accompanied by greater benefits.

Preservation of the environment is therefore treated as an "investment" that must compete with investment in other elements of the human economy. Every portion of the Earth, even the entire Earth, can be considered as no more important than a fungible part of the larger human economy. As that economy grows forever, the benefits provided by the Earth become an ever-smaller fraction of the economy until they seem to disappear all together in the distant future. As we pursue endless growth in net benefits, we need not be too concerned with the cumulative costs, including even severe ecological damage. According to this pre-analytic vision, each increment of damage must be worth the accompanying benefits. We can choose to obtain environmental "amenities" whenever we decide we can afford them, if not now, then later when we are richer and can buy them with other forms of accumulated capital. Those sensitive souls who mourn the environmental

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<sup>54</sup> *Id.* (detailed presentation and critique of these assumptions of mainstream, neoclassical economics). See also DALY & FARLEY, *supra* note 2, at 15, 35, 223–44.

losses must have insufficient appreciation for the greater gains we surely are obtaining.

This logic leads to an environmental law that seeks to police the economy by regulating mainly where the benefits of the regulation outweigh the costs; it contains no general principle of ecological preservation.<sup>55</sup> The economy and its governing law are structured around the assumption that there is no part of the Earth that we must have, no part we cannot learn to live without, no part we cannot replace with human-made capital. Our laws presume we can and should sacrifice every part of the Earth unless the legal system can show that in a particular case the cost of doing so outweighs the benefits. The reason we have no market or legal constraints on the total scale of ecological damage is because we assume that we do not need them.

Modern economic and legal thought profoundly is committed to these endless-growth assumptions. Even when the specter of large-scale future ecological degradation appears in the discounting literature, authors often revert to reminders of the assumptions upon which the cost-benefit decision-making enterprise rests. For example, John Graham, the leader of the OMB's approach to federal regulatory analysis during much of the last decade, recently wrote in support of OMB's use of discounting that U.S. regulators should "almost always" assume they are evaluating small projects with no economy-wide implications:

That is because (a) the U.S. economy is only one part of a huge and growing world economy, and (b) a single regulation is rarely expected to have a discernible impact on the overall growth path of the U.S. economy. Even in the case of policies to address global climate change, we should not assume that general equilibrium approaches to analysis [of the entire economy] will be required. The U.S. economy, for example, is far less sensitive to changes in energy prices than it was thirty or fifty years ago. Moreover, climate change policies that have a significant impact on the overall U.S. economy are not likely to be politically feasible.<sup>56</sup>

Similarly committed are Professor Cass Sunstein and Arden Rowell, even though, as we have seen, they are troubled enough by large-scale ecological degradation to suggest that our moral obligations to future generations should be "uncoupled" from questions of discounting. Nevertheless, they offer

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<sup>55</sup> See Guth, *Law for the Ecological Age*, *supra* note 3, at 462–69, 472–73 (U.S. environmental law contains no general means for containing scale of cumulative environmental impacts); Guth, *Cumulative Impacts*, *supra* note 3. See also Cass R. Sunstein, *Cost-benefit Default Principles*, 99 MICH. L. REV. 1651, 1665–66, 1668, 1716 (2001) (supporting reliance on cost-benefit analysis in implementing environmental laws); REVESZ & LIVERMORE, *supra* note 3, at 12–13 (cost-benefit analysis enables the net benefits of regulation to be maximized and ensures that regulations will increase the overall net wealth of society).

<sup>56</sup> Graham, *supra* note 14, at 51–55.

little progress toward an alternative decision-making structure because they cannot help reverting to endless-growth assumptions:

Some people believe that current generations are obliged not to make the environment worse than it is today. On this view, current generations are environmental trustees. As such, they must follow a kind of environmental nondegradation principle. But there is a problem with this position, which is its selective focus on environmental quality. Suppose that the current generation sacrifices a remote island, but that as a direct result of that action, it is able to confer significant economic, medical, and other benefits on posterity, giving them healthier, longer, and better lives. Is it so clear that the sacrifice is morally unacceptable?<sup>57</sup>

These same analysts support the notion of preventing “irreversible” environmental change but caution against taking this idea too far, again unable to escape the endless-growth assumptions:

But environmental protection can burden the future too, especially if it is extremely costly, and there is no abstract reason to believe that preserving a particular environmental amenity (a forest, a lake) is always better for posterity than other investments that do not involve the environment in particular (expenditures on basic research, reductions in national debt).<sup>58</sup>

For these analysts, no reason exists for a “selective focus on environmental quality.” Therefore, we should be willing to sacrifice every environmental “amenity,” every “remote island,” and every “forest and lake” whenever we think we can obtain greater benefits.

Similarly, Professor Revesz has suggested a set of ethical principles rather than discounting to inform our obligations to future generations. Ultimately, however, he also is unable to disengage from endless-growth assumptions when it comes to protecting the global environment. When considering the idea of sustainable development and environmental preservation, Revesz considers environmental projects only in isolation.<sup>59</sup> He concludes that “it does not make sense to undertake environmental expenditures for the benefit of future generations if the investment can yield higher benefits elsewhere.”<sup>60</sup> The best he can offer, on the environment at least, is that we might “seek to prevent catastrophic harms and the

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<sup>57</sup> Sunstein & Rowell, *supra* note 26, at 200.

<sup>58</sup> *Id.* at 205.

<sup>59</sup> Revesz, *supra* note 42, at 1009.

<sup>60</sup> *Id.* at 1015.

destruction of unique natural resources.” However, defining those, he admits, may be “hard.”<sup>61</sup>

#### IV. THE SOURCE OF THE DISCOUNTING “PARADOXES”

The endless-growth assumptions to which our society is so committed seemed reasonable, no doubt, a century or two ago, when the human enterprise was but a fraction of the size it is today. In that “empty” world—with comparatively few people living low-impact lives surrounded by seemingly boundless resources and pollution sinks—it might have seemed reasonable to unleash costs and benefits to grow forever.<sup>62</sup> For that is the path we took as we adopted our current economic and legal structures to promote the Industrial Revolution.<sup>63</sup>

What is happening in the discounting conundrums described in the previous Sections of this Article, is that the pre-analytic vision of endless growth in costs and benefits is being extrapolated from the empty world that gave it birth to a distant future and to very large scales of economic growth and ecological degradation. And there paradoxes abound. For the empty-world, endless growth assumptions that our prevailing economic and legal systems are built upon have become invalid. The world that has come upon us is an empty one no longer.

The global scientific community is reporting that ecosystems in virtually all regions of the Earth are being degraded at unprecedented rates.<sup>64</sup> In 2005, an in-depth review of the global environment organized by the United Nations demonstrated that 60 percent of global ecosystem services are “being degraded or used unsustainably,” including fresh water supplies, capture fisheries, air and water purification, and the regulation of natural hazards and pests.<sup>65</sup> More recently, the United Nations concluded that current trends in environmental degradation threaten human development and overall well-

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<sup>61</sup> *Id.*

<sup>62</sup> See John G. Sprankling, *The Antiwilderness Bias in American Property Law*, 63 U. CHI. L. REV. 519, 529–32 (1996) (documenting the widespread social view at the turn of the Nineteenth Century that the vast American wilderness was essentially valueless and should be brought under cultivation).

<sup>63</sup> MORTON J. HORWITZ, *THE TRANSFORMATION OF AMERICAN LAW 1780–1860*, at 74–108 (1977) (discussing history of Nineteenth Century changes in legal system designed to promote industrial revolution); Guth, *Law for the Ecological Age*, *supra* note 3, at 450–73 (reviewing findings of legal historians showing legal accommodation of social desire for industrialization, especially including development of modern doctrines of nuisance and negligence).

<sup>64</sup> These next few passages are adapted from Guth, *Cumulative Impacts*, *supra* note 3.

<sup>65</sup> MILLENNIUM ECOSYSTEM ASSESSMENT, *ECOSYSTEMS AND HUMAN WELL-BEING: SYNTHESIS 2* (2005), available at <http://www.millenniumassessment.org/documents/document.356.aspx.pdf> [hereinafter MILLENNIUM ASSESSMENT]. The Millennium Ecosystem Assessment is an evaluation of the world’s ecosystems and human well-being that was carried out by over 2000 scientists from ninety-five countries between 2001 and 2005 under the auspices of the United Nations. *Id.* at ii–ix. The reports are available at <http://www.millenniumassessment.org/en/index.aspx>.

being.<sup>66</sup> It identified many elements of the environment that are being degraded<sup>67</sup> and concluded that we are now crossing thresholds of sudden irreversible environmental changes. It reported the collapse of fisheries, dead zones in the sea, regional climate change, and loss of species, and warned that it is difficult to know exactly where more thresholds lie or when they might arise.<sup>68</sup> The World Wildlife Fund and its collaborators found that their biodiversity index has declined by 27 percent in the last thirty-five years.<sup>69</sup> They also found that by the 1980's, humanity's "Global Ecological Footprint" had reached the capacity of the biosphere to provide resources and absorb waste, that by 2003 it had overshot that capacity by 25 percent, and that it continues to grow every year.<sup>70</sup> They concluded that humanity is now depleting reserves of ecological assets that accumulated on the Earth over long periods of time, and that we cannot do so much longer without damaging the Earth's ability to renew them.<sup>71</sup>

Scientists have documented similar extensive degradation of ecosystems across the United States as well.<sup>72</sup> Americans have among the largest per capita ecological footprints of all people in the world.<sup>73</sup> Despite the federal environmental laws of the last few decades, which resulted in some improvements, serious environmental problems have persisted or even worsened.<sup>74</sup> Long-time leading American environmentalist James Gustave Speth recently concluded that despite current U.S. and global environmental laws, "we are losing the planet."<sup>75</sup>

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<sup>66</sup> U.N. ENV'T PROGRAM, GLOBAL ENVIRONMENT OUTLOOK—ENVIRONMENT FOR DEVELOPMENT GEO 4, 6 (2007), available at [http://www.unep.org/geo/geo4/report/01\\_Environment\\_for\\_Development.pdf](http://www.unep.org/geo/geo4/report/01_Environment_for_Development.pdf) (this report was prepared by over 400 scientists and environmental policy makers).

<sup>67</sup> *Id.* at 202 (box 6.1).

<sup>68</sup> *Id.* at 362–63.

<sup>69</sup> Ben Collen et al., *Living Planet Index, in 2010 AND BEYOND 4* (Jonathon Loh ed., 2008), available at [http://www.wwf.org.uk/filelibrary/pdf/2010\\_and\\_beyond.pdf](http://www.wwf.org.uk/filelibrary/pdf/2010_and_beyond.pdf) [hereinafter 2010 AND BEYOND] (reporting on index of biodiversity which comprises 4000 populations of 1477 vertebrate species from around the world).

<sup>70</sup> *Id.* at 1 (Fig. 2), 8–9.

<sup>71</sup> *Id.* at 9.

<sup>72</sup> See REED F. NOSS ET AL., U.S. GEOLOGICAL SURVEY, ENDANGERED ECOSYSTEMS OF THE UNITED STATES: A PRELIMINARY ASSESSMENT OF LOSS AND DEGRADATION (1995) (unpaginated document), available at <http://biology.usgs.gov/pubs/ecosys.htm> (reporting "more than 30 critically endangered, 58 endangered, and more than 38 threatened ecosystems" in the United States).

<sup>73</sup> 2010 AND BEYOND, *supra* note 69, at 3 (tbl. 1), 14–15, 16, 18, 19, 28.

<sup>74</sup> JAMES G. SPETH, THE BRIDGE AT THE EDGE OF THE WORLD—CAPITALISM, THE ENVIRONMENT, AND CROSSING FROM CRISIS TO SUSTAINABILITY 71–78 (2008) (outlining current environmental problems in the United States). See also Mary Wood, *Nature's Trust: Reclaiming an Environmental Discourse*, 25 VA. ENVTL. L.J. 431, 432–36, 440–47 (2007) (outlining failure of U.S. environmental law).

<sup>75</sup> SPETH, *supra* note 74, at 78. See also MILLENNIUM ECOSYSTEM ASSESSMENT, LIVING BEYOND OUR MEANS: NATURAL ASSETS AND HUMAN WELL-BEING 5 (2005), available at <http://www.precau>

These reports also explain the root cause of these ecological problems: the cumulative impact of the myriad human activities that comprise the human ecological footprint. Billions of people acting individually and together in various enterprises are causing numerous and diverse impacts on the Earth. These include climate disruption from greenhouse gas emissions, deforestation (from logging and agriculture), degradation of productive land (from desertification, erosion, and other processes), loss of freshwater watercourses and unpolluted water supplies for human use, depletion of marine fisheries (through over-fishing and destructive practices), discharges of toxic pollution (into air, water, and land), biotic impoverishment from loss of species, and over-fertilization with nitrogen leading to dead zones in the seas.<sup>76</sup>

The essential difficulty is that these growing impacts are being visited upon a biosphere that comprises no more than a thin film on the surface of the Earth. It has a finite physical size, containing only so much air, water, and land, so that environmental damage and pollution become concentrated as they accumulate. Because the various constituents of the biosphere are so deeply interdependent, our various impacts interact, each compounding the effects of the others. Moreover, the time scale on which the biosphere evolves is immense, so that losses of species and ecosystems are essentially permanent for us and accumulate with the passage of time. As a result of this inherently limited and interconnected nature, the biosphere has a limited capacity to assimilate ongoing ecological damage and still sustain the ecological systems we are so dependent upon.

We should not doubt the value of functioning ecological systems to human welfare. Indeed, since we cannot live without it, an ecologically functioning Earth is worth everything we have. As the summary of the United Nations 2005 Millennium Ecosystem Assessment Synthesis begins:

Everyone in the world depends completely on Earth's ecosystems and the services they provide, such as food, water, disease management, climate regulation, spiritual fulfillment, and aesthetic enjoyment.<sup>77</sup>

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tion.org/lib/livingbeyondourmeans.050315.pdf (introducing "bottom line" of Millennium Assessment: "Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted.").

<sup>76</sup> See SPETH, *supra* note 74, at 19–38. See also 2010 AND BEYOND, *supra*, note 69, at 2–3 (classifying myriad human impacts into five categories: habitat loss, overexploitation of species, pollution, spread of invasive species or genes, and climate change); U.N. ENV'T PROGRAM, *supra* note 66, at xxii–iii (classifying human pressures on the environment into categories of land use, resource extraction, external inputs (such as fertilizers, chemicals, irrigation), emissions (of pollutants and waste), and modification and movement of organisms).

<sup>77</sup> MILLENNIUM ASSESSMENT, *supra* note 65, at 1. See also EDWARD O. WILSON, THE CREATION: AN APPEAL TO SAVE LIFE ON EARTH 26–36, 62–69 (2006) (discussing deep biological dependence of human beings on the Earth).

Nor should we harbor any doubt that we can destroy the capacity of the Earth to sustain us. Our own history proves that this is the case. Scientists have shown that many past civilizations have used their resources unwisely, outgrown them, and collapsed.<sup>78</sup> This continues today as societies deplete the resources upon which they have long depended and then decline or move away, having overused their means of survival and then proved unable to invent a new one. The notion is false that this cannot happen on a global scale, that we can always substitute technology or new resources for those that we deplete, and that there is no part of the Earth that we truly need. That idea is not derived from science or history. It is a fantasy of the economist's imagination, made necessary by the hopes for endless growth of costs and benefits in a world that, as science is making all too clear, is finite and exhaustible.<sup>79</sup>

In several centuries or more, the endlessly growing economy of the discounting projections will be many hundreds or even thousands of times larger than it is today. Under our current market structure, absent further legal intervention to preserve the environment, the ecological footprint of such an economy would be vastly larger than today's. Such a footprint would assuredly be far beyond the Earth's ecologically sustainable limits, for the biosphere does not somehow grow along with the economy in its ability to accommodate the human footprint. It does not steadily grow ever more lakes, forests, or islands. Though discounting may make sacrificed islands, forests, and lakes seem mathematically to shrink to nothing in the future, the physical reality of those losses is real and permanent. A few portions of the biosphere may seem recoverable at our option, such as air free of short-lived pollutants. But for the most part, in the future we will not be able at any price to reconstitute the soils, productive oceans, forests, and species constituting the web of life that we think we cannot afford to save in the present. Many of these "amenities," once sacrificed, will be irretrievably gone forever.

As our cumulative impacts approach and exceed the Earth's ecological limits, cost-benefit analysis becomes useless for evaluating the reasonableness of each individual impact on the environment. In an empty world, each incremental impact might have caused tolerable harm or even, as in the case of small increments of greenhouse gas emissions, no harm at all. But under conditions of ecological overshoot leading inevitably to devastation of the biosphere's ecological systems, each incremental impact contributes to

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<sup>78</sup> See generally JARED DIAMOND, *COLLAPSE: HOW SOCIETIES CHOOSE TO FAIL OR SUCCEED* 18–19 (2005).

<sup>79</sup> Some economists have criticized strongly the endless-growth assumption that man-made capital is infinitely substitutable for natural capital, and argued that we must have policy interventions if we are to ensure that we pass a legacy of natural capital on to future generations. See, e.g., DALY & FARLEY, *supra* note 2, at 15, 35, 223–44; Kysar, *supra* note 30, at 126–28; DALY, *supra* note 53.

a total loss that is immeasurable. This immeasurable, indeed infinite, loss cannot be meaningfully allocated among the various increments of damage.<sup>80</sup>

The resolution of the paradoxes of discounting, then, is this: while each small part of the ecologically-functioning biosphere may seem dispensable for some finite gain, the entire biosphere, though finite and composed only of these small parts, is nevertheless indispensable. While any individual island, lake, or forest has a finite value, the ecological functioning of the Earth as a whole has an immeasurable value. We can sacrifice any of the individual parts, but we cannot sacrifice the whole. An increment of environmental damage that seems affordable in an empty world cannot be projected at that value (or at a discounted lesser value) into a distant future where the total cost of the cumulative increments of damage will have become infinite. An economy that sells off bits and pieces of the Earth without means for recognizing they are parts of an invaluable whole cannot be projected into a future in which that economy is assumed to grow forever. While in an empty world, individual portions of the biosphere might be assumed to be fungible fractions of the ever-growing human economy, this assumption cannot be extended to the biosphere as a whole.

#### V. CONCLUSION: TOWARD A NEW PRE-ANALYTIC VISION AND A NEW ENVIRONMENTAL DECISION-MAKING STRUCTURE

Because it is based on an outdated pre-analytic vision, our cost-benefit structure for making environmental decisions must be discarded. No rate of discounting, whether positive, negative, zero, or variable, can mold that structure into a form that can manage large-scale ecological degradation. Regardless of how discounting is employed, that structure remains saddled always with the paradox inherent in attributing definite and finite values to individual increments of environmental damage, and then projecting endless growth of such damage onto a finite biosphere.

Instead, we must form a new pre-analytic vision comprising a new set of starting assumptions. We must accept the message from the scientific community about the full world that has come upon us: the growing cumulative impact of the human footprint is threatening the ecological integrity of the biosphere that we need to survive and prosper.

The law must incorporate this reality into a new framework for making environmental decisions. As its most essential feature, a new framework should adopt the goal of maintaining an ecologically functioning biosphere by restraining the cumulative impact of our environmental damage to an ecologically sustainable scale.

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<sup>80</sup> See Kysar, *supra* note 30, at 129 (arguing that the assumption that all our projects are small can lead to an intolerable result if applied across the economy, noting that global fishery depletion is the result of cumulative "local" fishery collapses).

To be sure, we cannot live without having some impact on the environment and we should permit our economy to continue to develop and improve human welfare. But we need the law to prevent the developing economy from undermining the ecological systems that the public welfare depends so profoundly upon.<sup>81</sup> Such a legal structure would build on the instincts of many cost-benefit analysts to exempt “catastrophic” and “irreversible” environmental problems from discounting, but it would recognize that the ecological threat we face results from myriad small impacts and not just a handful of special cases.

This reorientation would constitute a dramatic evolution of the law. And yet, legal structures capable of restraining cumulative environmental impacts do exist, and in fact have long existed in American law. The lesson from these examples is that the law should establish a standard of environmental or human health necessary for the long-term public welfare, and then defend that standard from being invaded by the accumulation of small impacts.<sup>82</sup>

Examples of this legal approach can be found in old common law rules grounded in the ancient principle of “do no harm” under which the law was able to protect such interests as the public’s right to navigable waters from being interfered with by industrial discharges from numerous sources.<sup>83</sup> Examples can also be found in the modern federal environmental statutes under the Clean Air Act’s National Ambient Air Quality Standards, the Clean Water Act’s Water Quality Standards, the Endangered Species Act, and the Clean Air Act’s cap-and-trade system for sulfur dioxide.<sup>84</sup>

Legal writers have begun to extend these legal structures to ecological degradation writ large, including proposals for new principles of tort law designed to preserve ecological integrity, for constitutional environmental rights for future generations, and for capping and allocating the global human footprint.<sup>85</sup> Legal elements commonly found in these proposals include definitions of a standard of environmental or human health that the law should protect, legal barriers to all acts that contribute to invasion of

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<sup>81</sup> DALY, *supra* note 53, at 31–60 (distinguishing economic “development”—defined as improvement in quality of products but within a fixed ecological impact—from economic “growth”—defined as quantitative increase in total scale of throughput).

<sup>82</sup> See Guth, *Cumulative Impacts*, *supra* note 3 (discussing legal structures that can prevent cumulative impacts).

<sup>83</sup> See *id.* (discussing old common law cases controlling cumulative impacts).

<sup>84</sup> See *id.* (discussing setting of standards and control of cumulative impacts by certain provisions of federal environmental laws).

<sup>85</sup> See *id.* (discussing proposals by legal writers for legal strategies for controlling scale of ecological damage and creating environmental rights in future generations); Guth, *Law for the Ecological Age*, *supra* note 3, at 494–511 (proposing tort of ecological degradation); World Wildlife Fund, Zoological Society of London and Global Footprint Network, *Living Planet Report 2006*, at 25, available at [http://assets.panda.org/downloads/living\\_planet\\_report.pdf](http://assets.panda.org/downloads/living_planet_report.pdf) (proposing capping and allocating human footprint).

such a standard, placing the burden of proof on those whose actions threaten the environment, recognizing broad standing to enforce such rules of law, and a focus on motivating development of less-damaging alternatives. Under such new decision-making structures, cost-benefit analysis and even discounting might continue to help us choose among less damaging alternatives, but they would no longer be used to justify incremental contributions to ecological degradation.

We live in a transitional time. We are struggling to control mounting environmental degradation using a legal system that is ill-suited to the task because it is built on a pre-analytic vision that is no longer valid. The paradoxes of discounting are telling us that this is so. The resolution of these paradoxes is also telling us what we must do. For both our own welfare and that of future generations, we must build a new environmental law specifically designed to maintain the ecological integrity of the biosphere against the onslaught of cumulative impacts.